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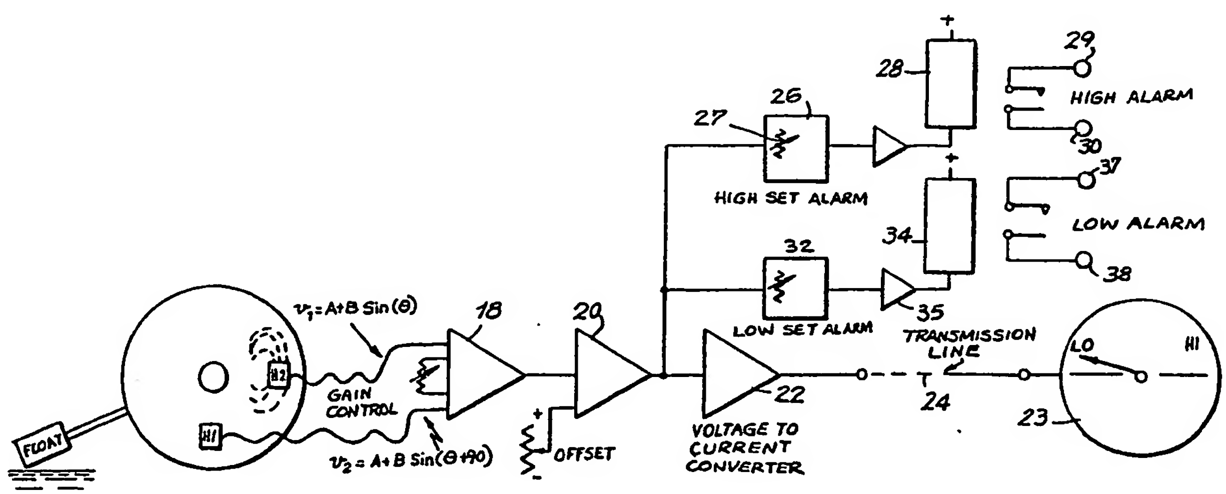

(57) Abstract

A liquid level sensor method and apparatus for use in sensing the level of coolant oil in an electrical power transformer by using a hall effect device to sense any change in a magnetic field which results from a change in a magnet's position as the liquid level changes.

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HALL EFFECT LIQUID LEVEL SENSOR SYSTEM

FIELD OF INVENTION

This invention relates to liquid level sensing systems including systems used to determine the cooling oil level in electrical power transformers.

DISCUSSION OF THE PRIOR ART

Presently known level gauges consist of a float driven magnet on one side of a metal flange and a follower magnet coupled to a pointer on the other side. The pointer provides an indication of float position and, therefore, level in a sealed tank.

SUMMARY

The present invention includes methods and apparatus for using a hall-effect device on the outside of the liquid-containing tank, with appropriate circuits, to indicate the liquid level by tracking the magnet in the tank.

DESCRIPTION OF FIGURES

FIG. 1 is a partial cross-sectional view of one embodiment of a hall-effect liquid level sensor system.

FIG. 2 is a partial cross-sectional view of a second embodiment of the invention.

FIG. 3 illustrates the hall effect principle.

FIG. 4 illustrates the output voltages as generated by the Hall effect device under the control of a rotating field;

FIG. 5 is a partial schematic block diagram of a hall effect liquid level sensor system.

DESCRIPTION

The invention relates to methods and apparatus for detecting the liquid oil level in electrical power transformers by using hall effect devices to detect changes in the liquid level.

Fig. 1 illustrates a liquid level detector mounted on a power transformer having walls 2 and liquid coolant oil 4. A float 5 is connected to a rotatable magnet 6 by the arm 7 supported by bearing 8 in inner housing 9. As the liquid level changes the float moves and rotates the magnet 6. The hall effect sensor 10, mounted proximate the non-magnetic seal 11 detects changes in the magnetic field due to movement of the magnet 6 and the electronics 12 responds to the changes in the magnetic field so as to generate electrical information that may be used to activate indicators to display quantitative or limit information concerning the liquid level. The Hall effect sensor 10 and electronics 12 are mounted in external housing 13 which has a fitting 14 for passage of the electrical conductors 15 to the external circuitry.

The level to be detected may be of any substance but in the preferred embodiment, the oil level of a power transformer is the level to be detected.

The method of the invention comprises generating a variable magnetic field in accordance with variations in the level of the substance in a container and detecting variations in the variable magnetic field representative of different levels of the substance in the container.

A Hall Effect sensor as shown in Fig. 3 operates on the principle that a magnet field applied across a current carrying material such as a semiconductor causes Negative charges to deflect from one side to the other along a conductor. The resulting potential difference referred to as the Hall Effect or Voltage (V_H)

Thus: $V_H \propto I * H$

I = Current

H = Magnetic Field Intensity

The Hall Effect device is a sensor. As the intensity of the magnetic field varies as the magnet rotates, the Hall effect device senses this change in magnetic field and produces an output voltage proportional to the magnetic field intensity.

Fig. 2 details an alternate magnet arrangement. Although shown as a circular magnet having singular "North" and "South" poles, the configuration could take on other shapes having similar outputs.

Two Hall-Effect sensors are shown in this design the object being to better stabilize the system under varying ambient or aging conditions.

Again the Hall sensors are located external to the chamber, and activated by the magnetically coupled field (H). As the magnet (6) rotates under the control of the float arm, a varying magnetic field is generated. This in turn generates a Hall voltage having an approximate sinusoidal wave shape as shown in Fig. 4.

Since the angle of travel under practical operational travel conditions is approximately ±70°, good linearity exists within the boundaries C to D.

True linearity is not a critical requirement but rather the preset conditions conforming to points of the curve are important. At "C" and "D" say alarms could be activated.

Fig. 5 further details the electronic circuitry. Outputs from Hall devices H1 and H2 are coupled to amplifier 18 which provides both signal gain and common mode signal cancellation.

Although the design of Fig. 5 includes two Hall sensors, a single sensor circuit could be used instead.

Amplifier 20 provides necessary offset voltage control. The output from 20 is fed to 22, a voltage/current converter. The output current of 22 is proportional to the angular displacement of the float 5. This current activates meter 23 either locally or remotely via a transmission line 24.

Still referring to Fig. 5, comparator 26 is preset by means of a high alarm control 27. Comparator 26 is next compared against the preset level. When preset is reached, relay 28 operates resulting in a contact closure 29 to 30.

Comparator 32 operates in a mode similar to comparator 26. In this case, however, relay 34 operates via the power driver 35. The contact closure 37 to 38 results in a low alarm output.

It is thus seen that methods and apparatus are provided to detect the level of a substance, such as the cooling oil of an electrical power transformer, by means of a Hall effect sensor, and the resultant sensed information utilized to provide indicated information and activate limit indicators.

Where movable magnets indicative of liquid level already exist inside a power transformer, external sensing apparatus may be modified by conversion to the use of a hall-effect sensor.

I claim:

1. A level sensing system comprising level detecting means including a movable magnet, and a hall effect sensing means responsive to the position of the movable magnet for detecting a change in the magnet's position.

2. A liquid level sensing system for use with a closed container having a varying level of liquid comprising,

float means within the container movable in response to variations in the level of liquid within the container,

rotatably magnetic field means within the container connected to the float means so as to be at least partially rotated upon movement of the float means,

stationary magnetic field sensing means outside the container for detecting variations in the position of the magnetic field caused by the partial rotation of the magnetic field of the rotatable magnetic means,

circuit means responsive to the said magnetic field sensing means for generating electrical information indicative of the position of the float means as detected by the rotatable magnetic field means, and

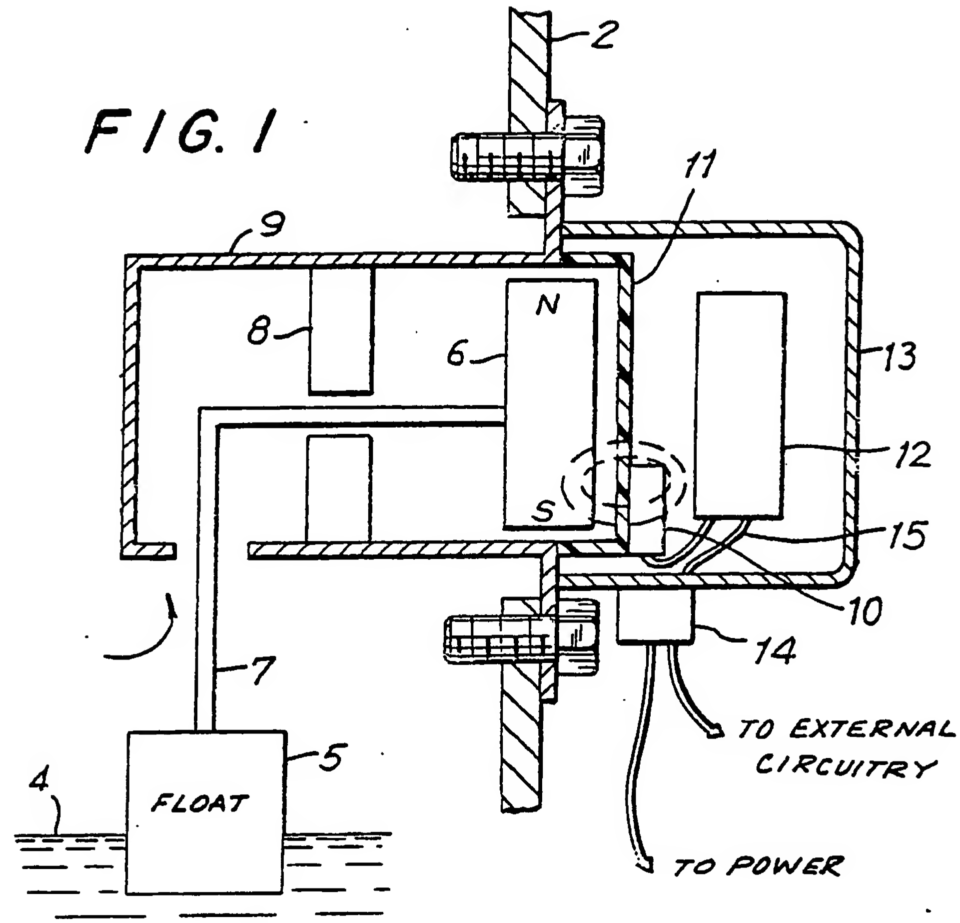
indicating means responsive to the electrical information generated by the circuit means for indicating the level of the liquid in the closed container.

3. A method of sensing the level of a substance in a container comprising

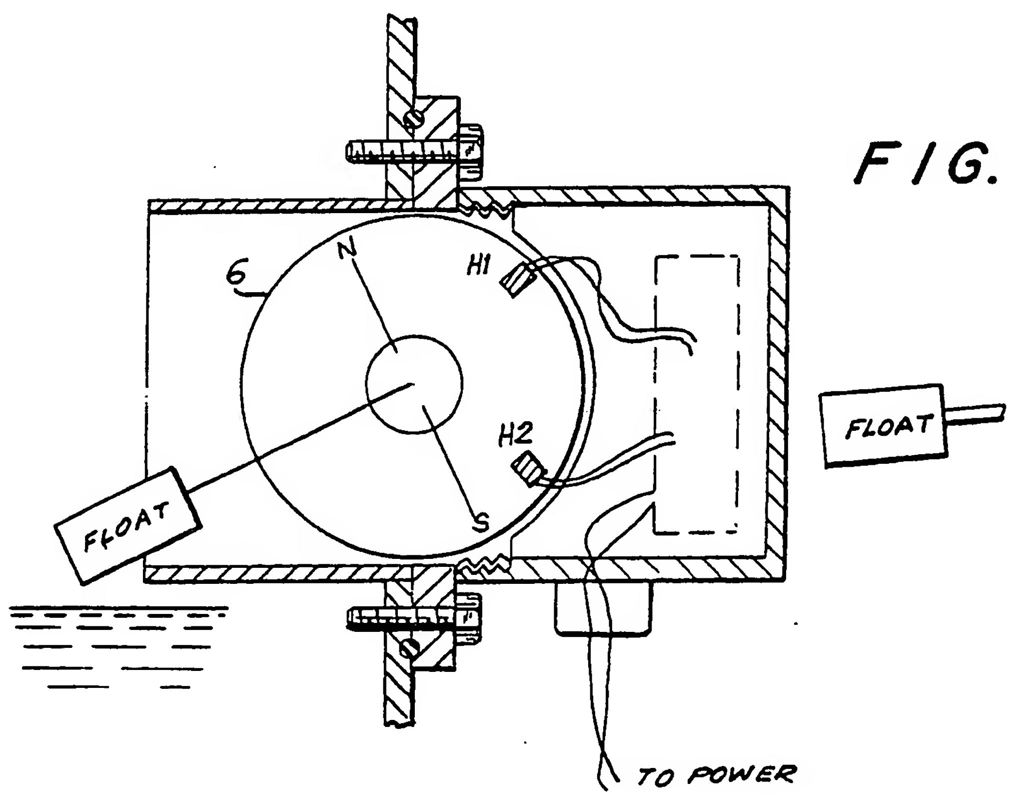
generating a variable magnetic field in accordance with variations in the level of the substance in a container,

detecting variations in the variable magnetic field representative of different levels of the substance in the container.

F I G. 1


2
11
9
8
N
6
13
12
S
15
10
14
7
TO EXTERNAL CIRCUITRY
5
4
FLOAT
TO POWER

F I G. 2


N
6
H1
H2
S
FLOAT
FLOAT
TO POWER

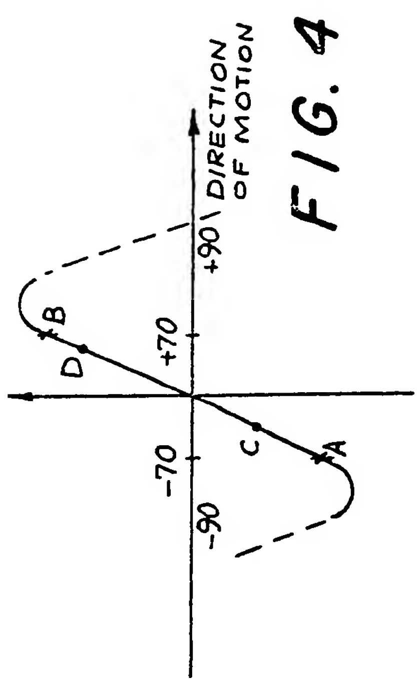


FIG. 4

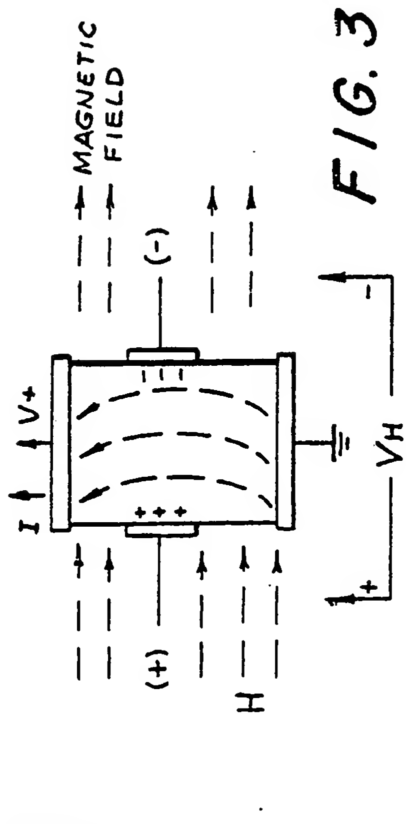


FIG. 3

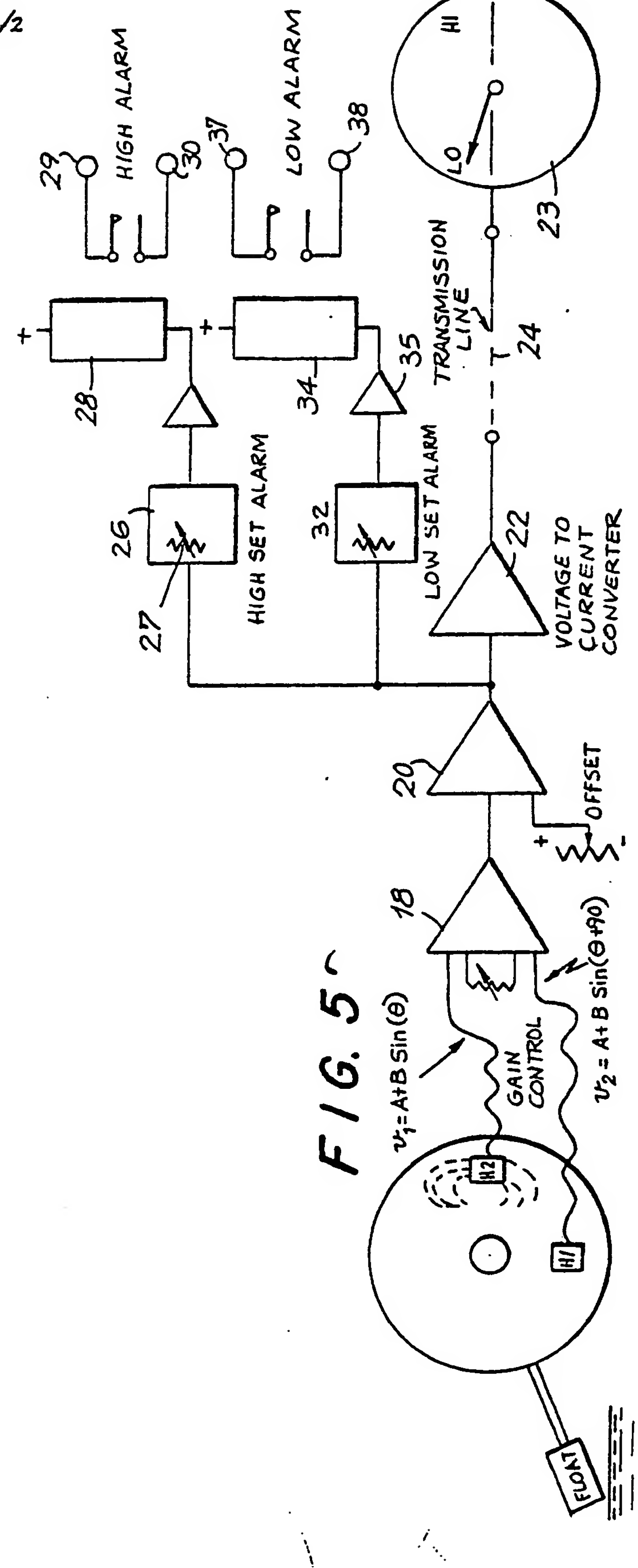


FIG. 5

INTERNATIONAL SEARCH REPORT

International Application No PCT/US 87/01803

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [8]

According to International Patent Classification (IPC) or to both National Classification and IPC

IPC^4: G 01 F 23/38; G 01 F 23/36

II. FIELDS SEARCHED

Minimum Documentation Searched [7]

Classification System	Classification Symbols
IPC^4	G 01 F

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [8]

III. DOCUMENTS CONSIDERED TO BE RELEVANT [9]

Category [*]	Citation of Document, [11] with indication, where appropriate, of the relevant passages [12]	Relevant to Claim No. [13]
X	DE, A, 2627865 (VDO ADOLF SCHINDLING) 5 January 1978 see figures and claims	1-3
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X	DE, A, 3233937 (KARL HOPT GmbH ELEKTRO-TECHNISCHE FABRIK) 15 March 1984 see abstract; page 8, last paragraph - page 10, paragraph 1; figures	1,3
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IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
6th November 1987	4 DEC 1987
International Searching Authority	**Signature of Authorized Officer**
EUROPEAN PATENT OFFICE	M. VAN MOL

Form PCT/ISA/210 (second sheet) (January 1985)

ANNEX TO THE INTERNATIONAL SEARCH REPORT ON

INTERNATIONAL APPLICATION NO. PCT/US 87/01803 (SA 18156)

This Annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report. The members are as contained in the European Patent Office EDP file on 16/11/87

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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
DE-A- 2627865	05/01/78	None	
DE-A- 3233937	15/03/84	None	

For more details about this annex :
see Official Journal of the European Patent Office, No. 12/82